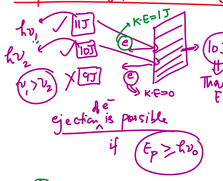
Explanation of photoelectric effect using planck's Q. Theory



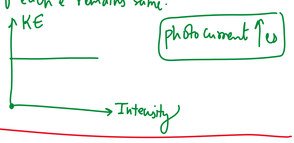
ejection of e⁻ is possible if $E_p \geq h\nu_0$

① one photon eject one e⁻ from metal surface.

② $E_p \geq W$ or $E_p \geq h\nu_0$

③ $E_p = W + (K.E)_e$ = Eq^n given by Einstein

④ Intensity of Radiation ↑es (Keeping ν same) means no. of striking photons ↑es & no. of photoelectrons ejecting ↑es & KE of each e⁻ remains same.



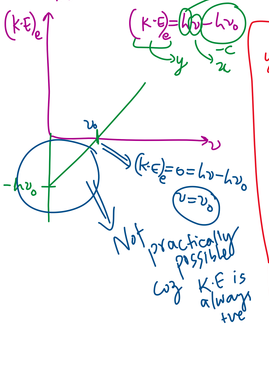
⑤ Frequency of radiation ↑es, E_p ↑es, W same

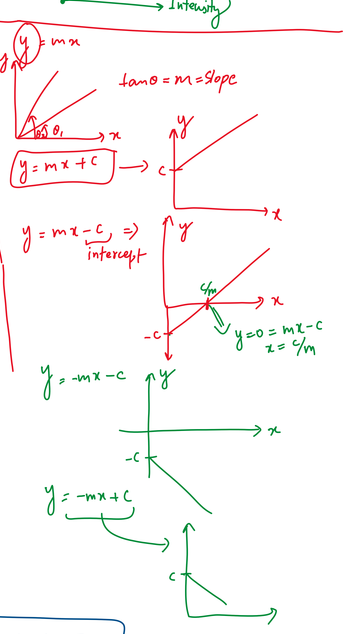
$(K.E) = (E_p - W)$ ↑es

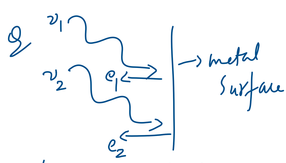
$E_p = W + K.E$

$h\nu = h\nu_0 + (K.E)_e$

$(K.E)_e = h\nu - h\nu_0$







Given $(K.E)_{e_1} = 2(K.E)_{e_2}$

$\nu_1 = 2 \times 10^{14}$ Hz

$\nu_2 = 0.5 \times 10^{14}$ Hz

$\nu_0 = ?$

Soln :- $(K.E)_{e_1} = 2(K.E)_{e_2}$

$h\nu_1 - h\nu_0 = 2(h\nu_2 - h\nu_0)$

$\nu_1 + \nu_0 = 2\nu_2 - 2\nu_0$

$\nu_0 = 2\nu_2 - \nu_1$

$= 2 \times \frac{1}{2} \times 10^{14} - 2 \times 10^{14}$

$= 1 \times 10^{14} - 0.2 \times 10^{14}$

$= (1 - 0.2) \times 10^{14}$ Hz

$= 0.8 \times 10^{14}$ Hz ✓

$= 8 \times 10^{13}$ Hz ✓

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$\lambda = 500\text{nm} = 500 \times 10^{-9}$ m

$E_p = h\nu = \frac{hc}{\lambda}$

$E_p = \frac{2 \times 10^{-25}}{500 \times 10^{-9}}$ J

$= \frac{2}{5} \times 10^{-18}$

$= 0.4 \times 10^{-18}$

$= 40 \times 10^{-20}$ J

1nm = 10^{-9} m

$hc = 2 \times 10^{-25}$ J·m

$\nu_0 = 4.3 \times 10^{14}$ Hz or s^{-1}

$h\nu_0 = W = 6.63 \times 10^{-34}$ J·s $\times 4.3 \times 10^{14}\ \frac{1}{s}$

$= 28.5 \times 10^{-20}$ J

$E_p = h\nu_0 + K.E$

$40 \times 10^{-20} = 28.5 \times 10^{-20} + \frac{1}{2} m_e v^2$

$\frac{1}{2} m_e v^2 = (40 - 28.5) \times 10^{-20}$

$v^2 = \frac{11.5 \times 10^{-20} \times 2}{9 \times 10^{-31}}$

$v^2 = \frac{23}{9} \times 10^{11} = 2.55 \times 10^{11}$

$= 25.5 \times 10^{10}$

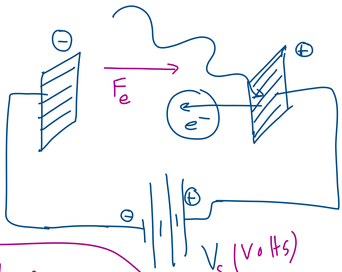
$v = \sqrt{25.5 \times 10^{11}}$ m/s

$= 5.2 \times 10^5$

$\approx 5 \times 10^5$ m/s ✓

Hw → Q-80, 82, 83, 85, 75, 52, 48, 36

Concept of stopping Voltage (V_s)



$(K.E)_e = eV_s$

1 C × 1 Volt → 1 Joule

St. voltage → Voltage applied to stop photoelectric effect.

K.E of e⁻ = 0 at V_s

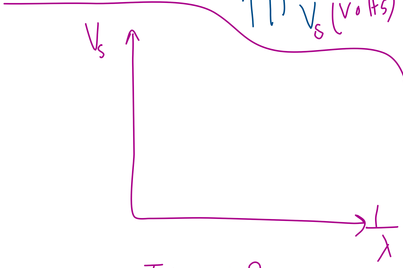
$E_p = W + (K.E)_e$

$E_p = W + eV_s$

$h\nu = h\nu_0 + eV_s$

$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + eV_s$

Note
for ejection of e⁻,
$\nu \geq \nu_0$
$\lambda \leq \lambda_0$



y - Intercept ?
Slope ?
x - intercept ?

$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + eV_s$

$eV_s = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

$V_s = \left(\frac{hc}{e}\right)\frac{1}{\lambda} - \left(\frac{hc}{e\lambda_0}\right)$

$m = \frac{hc}{e}$ → x

y-intercept $= -\frac{hc}{e\lambda_0}$

x-intercept $= \frac{1}{\lambda_0}$